Comments on Flood Frequency Analysis for the Congaree River at Columbia, South Carolina

U.S. Geological Survey

July 30, 2000

The U.S. Geological Survey evaluated the document, "Flood Frequency Analysis for the Congaree River at Columbia, South Carolina", at the request of Mr. Michael K. Buckley, Director of the Technical Services Division of the Federal Emergency Management Agency (FEMA). Our evaluation was limited because of the short deadline imposed by Mr. Buckley; however, we have been able to analyze the methods presented in the document as well as conduct some additional analyses of the data.

We cannot provide a definitive answer about which of the methods provides the best estimate of the 1-percent chance discharge, but we can provide some insight to narrow the choice. First, we do not think methods 1 or 4 are appropriate. Method 1 uses a weighted skew based on the regional skew from Bulletin 17B and the station skew. The regional skew is inappropriate because it was developed using data from unregulated streams with drainage areas less than 3,000 square miles. The Congaree River does not meet either of these conditions. Method 4 was not considered appropriate because of the low correlation between concurrent peak discharges of the Congaree River at Columbia and Tar River at Tarboro.

The other three methods discussed in the document have some deficiencies because of the uncertainty of the effects of Lake Murray. Methods 2, 3A, and 3B use the relation between the natural flows of the Broad River and the regulated flows of the Congaree River for the period 1930-1983 to estimate regulated flows on the Congaree River prior to 1930. Our analysis suggests that the operation of Lake Murray changed in about 1956, and, therefore, it may not be appropriate to use an equation that was developed with data from two different populations. Figure 1 shows the variation in the stage of Lake Murray between 1930 and 1999. The median lake level ranged from 333 to 351 feet between 1931 and 1955 and from 350 to 358 feet between 1956 and 1999. The higher reservoir levels after 1955 suggests that Lake Murray had less potential for attenuating flows flood discharges after 1955.

We developed a new relation between the natural flows of the Broad River and the regulated flows of the Congaree River for the period 1956 to 1983 to determine if the more recent operation of the Lake Murray produced substantially different results than methods 2, 3A, and 3B. The new relation was developed using the MOVE.1 technique. The resulting equation ($Q_{1695} = 0.3784\ Q_{1615}^{1.109}$) has the same slope as equation 3 in the FEMA document, but a greater intercept value, resulting in regulated flows that were generally higher than the FEMA study. The range of flows used to develop the revised equation for the 1956-83 period (31,000 to 155,000 cfs) was not as large as that used in the FEMA MOVE.2 relation (28,600 – 303,000 cfs). Thus the revised relation must be extrapolated for use in estimating the larger floods. This extrapolation resulted in three peaks over the 1892-1925 period in which the relation produced larger peaks at 02169500 than were observed. In these instances the observed flood peaks were used as if no regulation effect was present.

The revised peak discharges for the Congaree River were then used to compute the 1-percent chance discharge. The results of the FEMA and USGS analyses for methods 2, 3A, and 3B are listed below.

Approach No. (from FEMA document)	**Discharge for 1-percent-chance flood, in cfs**	
	FEMA study, equation 3 derived from 1930-83 data	Equation derived from 1956-83 data
2	275,000	283,000
3a	292,000	306,000
3b	304,000	319,000

Our preliminary analysis, based on the post-1955 data, has some obvious weaknesses because regulated flows were estimated that exceeded the limits of the data used to develop the equation. However, the analysis suggests that a closer examination of the effects of Lake Murray may be warranted.

We have not analyzed the historical data that were gathered prior to the beginning of the systematic record in 1892, but we concur with your decision to use the data prior to 1892 only to determine the high outlier threshold and historic period. At the same time, we think you would be remiss to not use all the systematic record, including the period 1892 to 1925. The question is how to accurately adjust the systematic record to account for the effects of Lake Murray. Comments 5 and 6 below suggest an alternative for estimating the peaks for 1897 to 1907. We may never find a completely valid method of adjusting the remaining systematic record, including the 1908 record peak. Therefore, it may be appropriate to weight the more defensible approach and less complete data of method 2 and the more questionable approach and more comprehensive data of method 3B.

In addition to considering some further examination of the effects of Lake Murray and the weighting of methods 2 and 3B, we suggest that the following editorial and technical suggestions be considered when revising the document:

1. Page 2, Summary of Approach 1, Adjustments – The dates in the description of the approach and the summary are inconsistent. Is the 1930 peak regulated or unregulated?
2. Page 5, Summary of Approach 2, Adjustments – The peak for 1930 cannot be used in the regression equation (1st sentence) and then used to estimate the 1930 peak (2nd sentence). The second "1930" should probably be "1929."
3. Page 6, line 7 – The exponent of 0.69 for the <u>Upper Coastal Plain</u> was used to compare the unregulated relation. However most, if not all, of the basin is in the <u>Piedmont</u> physiographic province (exponent = 0.63) so why not use that value? This would only change the factor in the drainage area ratio from 1.394 $((A_{1695}/A_{1615})^{0.69})$ to 1.354 $((A_{1695}/A_{1615})^{0.63})$.

4. Page 6, figure 2 – Where did the 100,000+ peak for the Broad River in 1929 come from? The peak flow files for the 1929 peak (9-28-29) shows a discharge of 88,200. Similarly, why is the 1936 peak displayed? This is well into the "regulated" period.
5. The peaks for at least the period 1897-1907 did not have to be estimated using equation 4. A station (Broad River at Alston, 02161000) was in place at the time and has a drainage area of 4790 sq mi, only 1 percent less than the Richtex station (4850 sq mi). The Alston data could have been substituted for the Richtex data in equation 3 to take advantage of that more accurate relation (based on more points than equation 4).
6. Page 11 – It is stated that a weakness of Approach 3 might be that the adjusted peak flows may be too high. Why couldn't they be too low? As a check, we computed the 1897-1907 peaks using the Alston data adjusted using equation 3. We found the adjusted peaks using the Alston data to be higher in 9 of 11 years (an average of 11% higher for all 11 years) than the value obtained using equation 4 and ultimately used in the analysis.
7. Page 12 – The third paragraph of "Independent Quantitative Checks" mentions an alternative analysis of the peak discharges of the Saluda River and the effects of Lake Murray. Is the 50 percent reduction in peak discharges based on Lake Murray being operated for flood control? This needs to be clarified.
8. Page 13, second paragraph, line 8 – Again, perhaps the exponent to be used here should be 0.63 (the value for the Piedmont physiographic province).
9. Page 15, Appendix 1 – The column headings for Congaree River and Broad River have been inadvertently reversed.

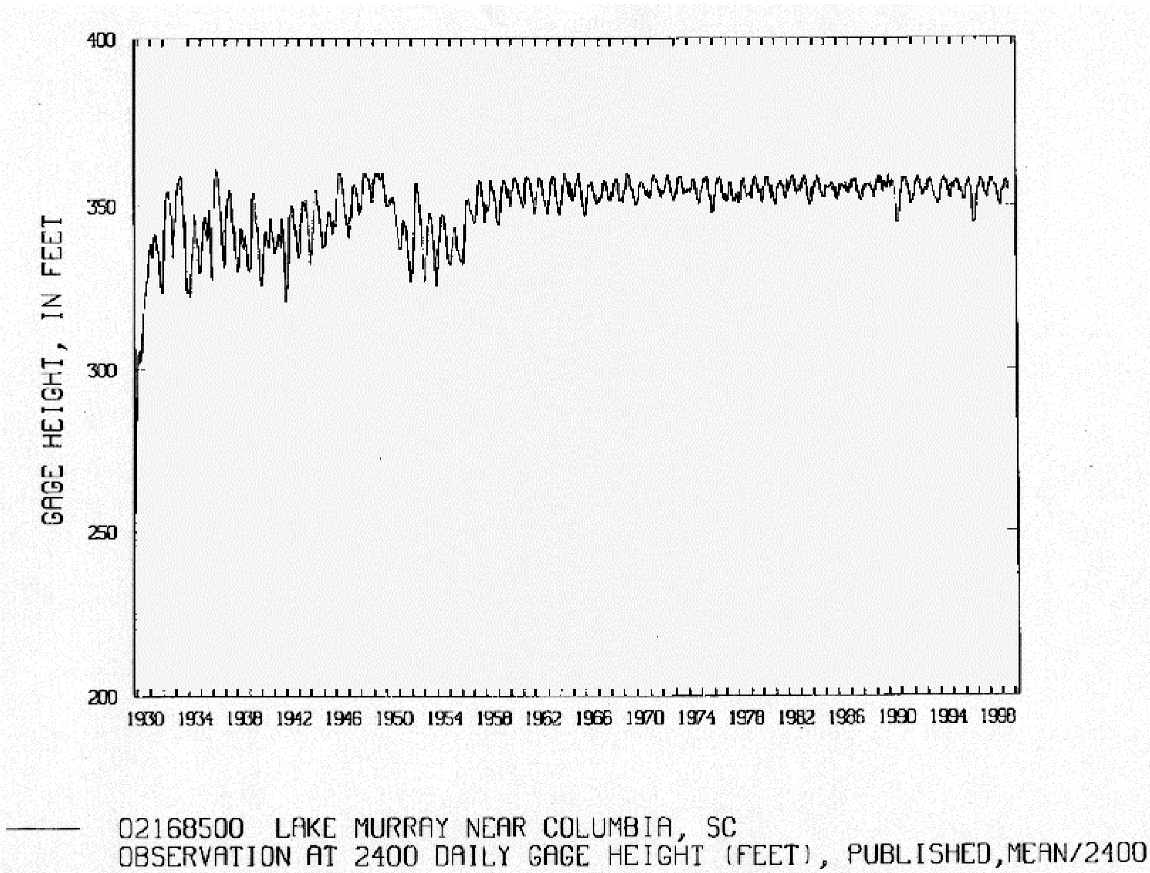
GAGE HEIGHT, IN FEET
400
350
300
250
200
1930 1934 1938 1942 1946 1950 1954 1958 1962 1966 1970 1974 1978 1982 1986 1990 1994 1998
02168500 LAKE MURRAY NEAR COLUMBIA, SC
OBSERVATION AT 2400 DAILY GAGE HEIGHT (FEET), PUBLISHED,MEAN/2400

FIGURE 1